

**CLAIMS**

Therefore, at least the following is claimed:

- 1           1.       A digital subscriber line (DSL) transceiver, comprising:  
2           a pulse amplitude modulation (PAM) transmitter;  
3           a fractional encoder associated with the PAM transmitter, the fractional encoder  
4           configured to encode a non-integer number of bits for each word to be transmitted by  
5           the PAM transmitter; and  
6           a constellation encoder configured to encode each word containing the non-  
7           integer number of bits into a signal space constellation to be transmitted by the PAM  
8           transmitter, and where each signal space constellation comprises a symbol.
- 1           2.       The transceiver of claim 1, wherein the signal space constellation is  
2           generated by the PAM transmitter.
- 1           3.       The transceiver of claim 1, wherein the fractional encoder further  
2           comprises a modulus converter.
- 1           4.       The transceiver of claim 1, wherein the fractional encoder further  
2           comprises a shell mapper.
- 1           5.       The transceiver of claim 1, wherein the fractional encoder further  
2           comprises a constellation switcher.

1           6.       The transceiver of claim 1, wherein each symbol is transmitted using a  
2       single dimensional signal space constellation.

1           7.       The transceiver of claim 1, wherein each symbol is transmitted using a  
2       multi-dimensional signal space constellation.

1           8.       The transceiver of claim 1, further comprising a trellis encoder associated  
2       with the constellation encoder.

1           9.       The transceiver of claim 1, wherein the fractional encoder is configured  
2       to collect an integer number of bits  $S \cdot K$ , over a frame comprising several symbol  
3       periods  $S$ , and is configured to encode the frame of  $S \cdot K$  bits for transmission at a  
4       fractional bit rate of  $K$  bits per symbol.

1           10.      The transceiver of claim 9, wherein the fractional encoder is configured  
2       to convert the  $S \cdot K$  bits of the frame into  $S$  integers, each of arithmetic base  $M$ , where  $M$   
3       corresponds to a plurality of PAM signal levels.

1           11.      The transceiver of claim 1, further comprising a fractional decoder  
2       configured to decode a received symbol into a non-integer number of bits.

1           12.      The transceiver of claim 11, wherein the fractional decoder is a modulus  
2       converter.

1           13.    A method for encoding fractional bit rates using pulse amplitude  
2 modulation (PAM), the method comprising the steps of:  
3           providing a PAM modulator;  
4           using the PAM modulator to generate a transmit signal; and  
5           encoding the transmit signal with a modulation symbol representing a non-  
6 integer number of bits, wherein the sum of the bits over a plurality of symbol times  
7 results in an integer number of bits.

1           14.    The method of claim 13, wherein the encoding step includes modulus  
2 conversion.

1           15.    The method of claim 13, wherein the encoding step includes shell  
2 mapping.

1           16.    The method of claim 13, wherein the encoding step includes constellation  
2 switching.

1           17.    The method of claim 13, wherein the modulation symbol is encoded into  
2 a multi-dimensional signal space constellation.

1           18.    The method of claim 13, wherein the modulation symbol is encoded into  
2 a single dimensional signal space constellation.

1           19.    The method of claim 13, further comprising the step of trellis encoding  
2 the modulation symbol.

1           20.     The method of claim 13, further comprising the steps of:  
2           collecting an integer number of bits  $S \cdot K$ , over a frame comprising several  
3           symbol periods  $S$ ; and  
4           encoding the frame of  $S \cdot K$  bits for transmission at a fractional bit rate of  $K$  bits  
5           per symbol.

1           21.     The method of claim 20, further comprising the step of converting the  
2            $S \cdot K$  bits of the frame into  $S$  integers, each of arithmetic base  $M$ , where  $M$  corresponds  
3           to a plurality of PAM signal levels.

1           22.     A digital subscriber line (DSL) transceiver, comprising:  
2           means for providing a PAM modulator;  
3           means for using the PAM modulator to generate a transmit signal, the transmit  
4           signal including a plurality of transmit symbols; and  
5           means for encoding each of the transmit symbols with a non-integer number of  
6           bits, wherein the sum of the bits over a plurality of transmit symbols results in an integer  
7           number of bits.

1           23.     The transceiver of claim 22, wherein the encoding means includes  
2           modulus conversion means.

1           24.     The transceiver of claim 22, wherein the encoding means includes shell  
2           mapping means.

1           25.     The transceiver of claim 22, wherein the encoding means includes  
2     constellation switching means.

1           26.     The transceiver of claim 22, wherein the transmit symbol is encoded into  
2     a single dimensional signal space constellation.

1           27.     The transceiver of claim 22, wherein the transmit symbol is encoded into  
2     a multi-dimensional signal space constellation.

1           28.     The transceiver of claim 22, further comprising means for trellis encoding  
2     each of the transmit symbols.

1           29.     The transceiver of claim 22, further comprising:  
2             means for collecting an integer number of bits  $S \cdot K$ , over a frame comprising  
3     several symbol periods  $S$ ; and  
4             means for encoding the frame of  $S \cdot K$  bits for transmission at a fractional bit rate  
5     of  $K$  bits per symbol.

1           30.     The transceiver of claim 29, further comprising:  
2             means for converting the  $S \cdot K$  bits of the frame into  $S$  integers, each of  
3     arithmetic base  $M$ , where  $M$  corresponds to a plurality of PAM signal levels.